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QUMRAN TEXTILES IN THE PALESTINE EXPLORATION FUND, LONDON: RADIOCARBON DATING RESULTS

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Three pieces of fabric from Qumran's Cave 1 have been stored in the Palestine Exploration Fund collection since the 1960s but have hitherto never been tested or re-examined. The fabric is made of linen, and was probably used for wrapping or packing scrolls, or sealing jars. New radiocarbon dating on one piece of fabric indicated a probability of 55% for it being made between 1 and 55 A.D., and a probability of 95.4% that it was made between 50 cal B.C.–80 cal A.D.

During a re-examination of the holdings of the Palestine Exploration Fund, London, three pieces of ancient textile were noted as coming from Ain Feshkha. These were mounted in perspex and labelled A.F. 20, A.F. 23, and A.F. 25 (see Figures 1–3). They were then identified as deriving not in fact from Ain Feshkha precisely but from Qumran Cave 1. In the earliest period of Dead Sea Scroll discoveries, when the first cave yielded jars containing scrolls, the cave was associated with the spring and ruin at Ain Feshkha rather than with Khirbet Qumran (Bélis 2003, 223). Accordingly, when the textiles found with the scrolls were first published it was in an article by Grace Crowfoot entitled 'Linen Textiles from the Cave of Ain Feshkha in the Jordan Valley' (Crowfoot 1951). Cave 1 is 12 km south of Jericho, 4 km north of Ain Feshkha, and about 1 km north of Qumran.

The three pieces of linen can be directly identified by reference to Crowfoot's article, and her later paper in the series *Discoveries in the Judaean Desert* [*DJD*], vol. 1 (1955). Crowfoot initially catalogued thirty-six pieces and mounted them in perspex, with the assistance of Dr Bushnell of the Museum of Ethnology and Archaeology, Cambridge. Therefore, the PEF items carry exactly the cataloguing numbers given by Crowfoot. A. F. no. 20 is shown in Crowfoot 1955 Pl. VI: 16; A. F. 23 in Crowfoot 1951, Pl. VIII: 1 and 1955: 17; A. F. 25 appears in Crowfoot 1951, Pl. III: 3 and 1955: 18. By the time of the publication of the first volume of *DJD* Crowfoot had a catalogue of seventy-seven pieces from Cave 1, though two of these (nos. 11 and 12) turned out to be modern.

The original provenance of the linen pieces in the PEF is described in a short article by G. Lankester Harding (1949). Harding, then working with the Antiquities Department of Jordan, excavated Cave 1 in 1949 with Father Roland de Vaux of the École Biblique et Archéologique Français. According to Harding, some jars containing scrolls had been broken in ancient times and the contents strewn around the floor of the cave, so that animal droppings then built up on top of the debris over time. Originally, most of the linen lay under a deposit of animal droppings 15 cm thick 'with fragments of linen adhering to the underpart of this deposit' (Harding 1949, 115). Harding also noted that the 'contents [of the cave] had been thoroughly turned over, and some of the rubbish thrown outside' (1949, 112) and that '[m]any sherds and much linen were lying about in the filling and the rubbish outside' (1949, 113). Crowfoot stated that the 'textiles of this study were collected from the floor of the cave' (1955, 18); however, given Harding's statements it cannot be said with certainty whether he

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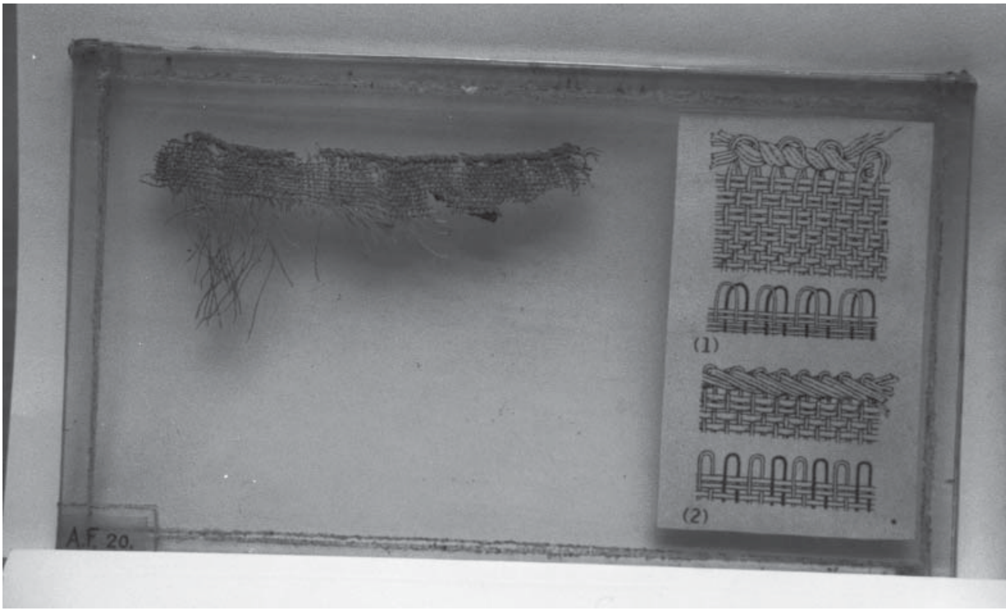

Fig. 1. Qumran linen: AF 20.

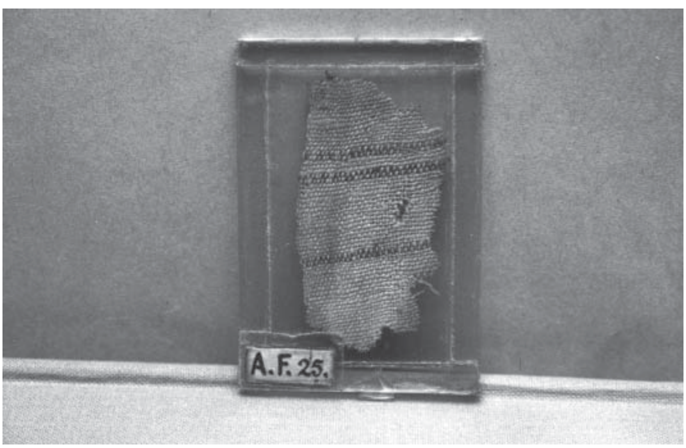

Fig. 2. Qumran linen: AF 25.

and de Vaux in fact collected any given sample from a disturbed or undisturbed location on the floor of the cave, from an undisturbed position under the 15 cm of animal droppings, or from the debris outside the cave that was thrown there when the cave was first explored by Bedouin some years earlier.

The linen itself Harding noted as being mostly 'of squares varying from 20–50 cms in size'. Crowfoot was able to refine this estimation. Full measurements of intact cloth could be determined in only ten cases. The largest cloth (no. 1.) was 57 × 60 cm The smallest (no. 32) was 27.2 × 23.2 cm However, there was also a 'ragged large cloth' composed of separate pieces (no. 63) that in total measured roughly 74 × 63 cm (Crowfoot 1955, 19).

While there were seventy-five different citations of ancient linen in Crowfoot's list, some of these were in pieces, and some should in fact be linked together, as Crowfoot noted. For

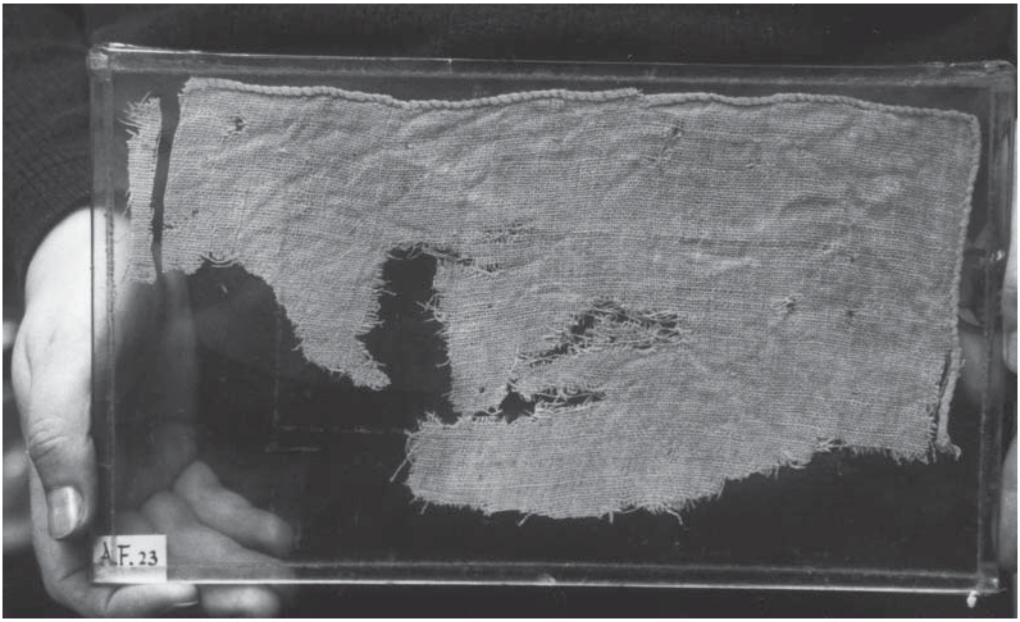

Fig. 3. Qumran linen: AF 23. The small detached piece in the top left corner was used for radiocarbon dating.

example, no. 18 belongs with no. 28, and no. 6 with 19. In total, Crowfoot estimated, the linen found in the cave represented at least forty and possibly well over fifty whole cloths (Crowfoot 1955, 19). Crowfoot herself distinguished between three types of materials: 1. cloths with a woven decoration of blue lines (or having stitching with blue thread), some with hanging warp threads that could represent a kind of fringe (nos. 1, 19, 42); 2. plain cloths, some with fringes; and 3. smaller (max. 29 cm × 25 cm for no. 15), coarser cloths used as jar covers, distinguished by at times having twisted corners, coarser weave (e.g. 10 × 8 warp/weft threads per cm in nos. 37 and 40) and, occasionally, attached string. The distinction between categories 1 and 2 was not considered by Crowfoot to indicate different uses; both were considered to be scroll wrappers. Harding (1949, 113) suggested that the linen was used not only for wrapping the scrolls but also for packing them in the pots, a point noted also by Crowfoot (1955, 19). Some pieces were found still folded into pads (Crowfoot 1955, no. 30, Pl. VII, 22). These were still believed to be scroll wrappers originally as many were 'fine and ornamented with fringes' (Crowfoot 1955, 24; no. 30 had a corded border).

This may be correct, but it is not certain. The blue-decorated pieces may have been made-to-measure (evidenced by two selvedges in no.1), though in no. 41 there is one rolled side edge, in no. 49 there is one side selvedge and the other side rolled and whipped. Of the fringed plain pieces, on the other hand, they invariably show indications of being cut down from a larger piece: nos. 2, 3, 4, 31, and 59 had their outside edges cut, rolled, and whipped or oversewn; nos. 2, 4, and 35 had one rolled and whipped edge and one selvedge; nos. 13, 17 and 37 had one side cut, rolled, and whipped and the other is unknown; and no. 72 had a selvedge with the other side unknown. This must raise the possibility that these were not custom-made scroll wrappers but perhaps linen used for clothing which was then cut down for use for some other purpose. Bélis (2003, 231) rightly notes that the fringes — some of which are open-spaced — would have been easily snagged and torn when used as scroll-wrappers and doubts they ever had such a use. In fact, Crowfoot notes that in one case of plain, fringed cloth (no. 37) there is a corner tied in a knot with a piece of string hanging from it, indicating that it was used as a jar cover. One cannot say conclusively that fineness or ornamentation with fringes in fact characterizes scroll-wrappers.

Scroll-wrappers could be custom made or cut from larger (previously used?) cloths. The non-fringed plain cloths are usually cut from larger pieces, invariably when used as jar covers but also for bigger sizes, though custom-made pieces are also found (no. 8?, 63). There was one example in which non-fringed plain cloth was sewn on to blue-decorated cloth, selvedge to selvedge (no. 52), and there was the discovery of a (plain) scroll-wrapper *in situ* with three hemmed edges and one selvedge (Crowfoot 1955, 18, Pls. 1, 8–10). The cloth was doubled and folded again and then wrapped around the scroll with the corners in the centre (i.e. not as shown in Bélis 2003, 236, Fig. 4). This indicates that scroll-wrappers could be cut, hemmed, and plain. Relative fineness of weave characterizes some examples, especially the blue-decorated cloth, but some blue-decorated cloth could be, according to Crowfoot, 'unusually thick' (no. 16) or coarse (no. 51, with only blue hemming thread indicating it came from a blue-decorated cloth).

One point to note in addition is that both Harding (1949, 114) and de Vaux (1949a, 235) note that some linen was impregnated with wax. In fact, de Vaux goes so far as to say it was often impregnated with wax, pitch, or asphalt: 'Ils sont souvent impregnés de cire, de poix ou d'asphalte'. Such substances may have been used in the sealing of the jars. On the other hand, the decomposed scroll found within its wrapper illustrated in *DJD*, vol. 1 (Pl. I, 8–10) was in appearance a 'solid black mass', and since decomposed leather could sometimes appear to be asphalt it may be that the black substance adhering to textiles was at times scroll

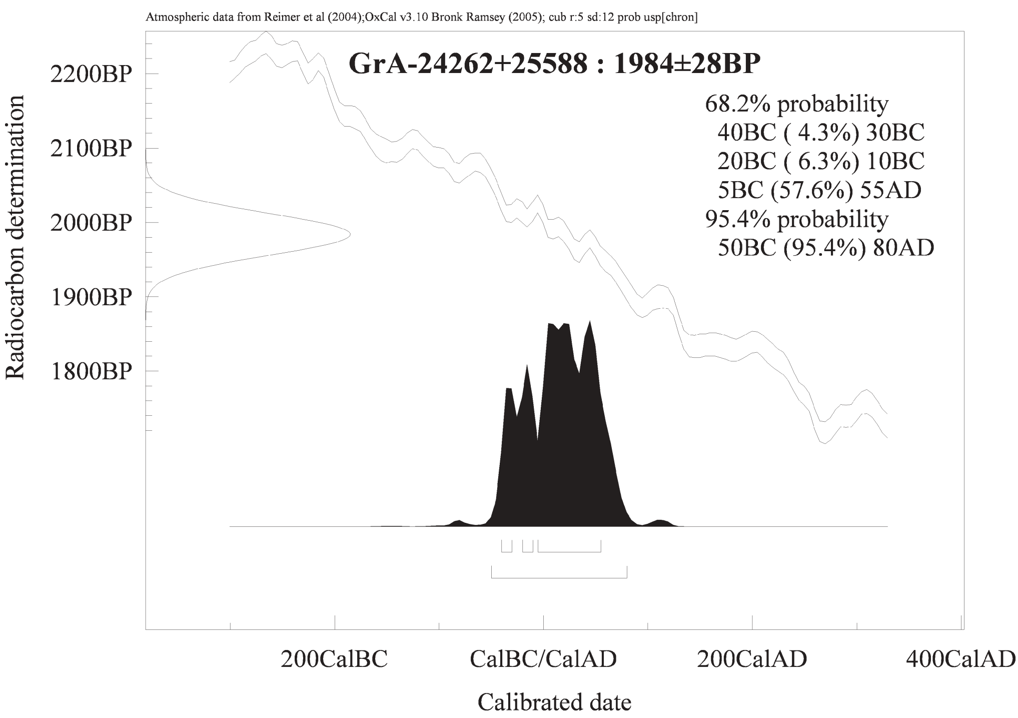

Fig. 4.

residue, though this must remain a speculative point. No testing of any possible wax, pitch, or asphalt on the textiles seems ever to have been done prior to cleaning.

The question of whether all the linen of Cave 1 was in some way used for scroll storage is interesting. Many of the identifiable jars were of the large cylindrical type used for storing scrolls; in fact there was only one small jar recovered not of this type (Milik and Barthelemy [*DJD*, 1] 1955, 8–13). De Vaux (1949b, 591) identified over fifty cylindrical jars originally deposited in the cave and noted that if on average there were three scrolls per jar then there were possibly 150 scrolls initially housed in Cave 1. After other caves were surveyed, however, it became clear that scrolls were not necessarily always placed for conservation in jars, and also that similar cylindrical jars could be used for other purposes, most importantly for storing food. De Vaux commented that 'les jarres [. . .] ont servi normalement à garder des provisions' (1962, 35). Harding doubted then that every cylindrical jar in Cave 1 should necessarily be deemed a container for scrolls: 'our first idea, that these [jars of Cave 1] must all have contained manuscripts, is no longer tenable' (1955, 3). It may have seemed wise to be cautious, but in fact it is now known for sure that there were at least seventy scrolls originally stored in Cave 1, as testified by the surviving fragments and scrolls. Any maximum number we care to suggest is arbitrary, but de Vaux's initial suggestion of 150 is not implausible. The large number of scrolls would have required a large number of jars. While cylindrical jars could be used for food or water elsewhere, the specific use of the jars in Cave 1 may well have been simply for scroll storage. The astonishingly uniform pottery assemblage (nearly all the jars were cylindrical) is distinctive, whereas in other contexts cylindrical jars are found with a range of other storage pottery. In addition, if each scroll had a linen wrapper, and if each jar was sealed with a linen jar-stopper and contained packing pads, then this would account for the significant quantity of linen that was found in the cave. We do not have to look for an alternative use of the jars since the scroll-container hypothesis successfully accounts for the available evidence in Cave 1. All one can say is that it is possible that some of the cylindrical jars were used as food containers, given their usage elsewhere, but no food was found in the jars. There was an unspecified 'quantity' of olive and date stones found on the cave floor. However, given that olives and dates have been common, portable snack foods for millennia they can be explained as the result of meals or snacks eaten in the cave by those who stored or disturbed the scrolls in antiquity. The accessibility problem of Cave 1 would have made food storage in this locality, as opposed to some other sites, unlikely since the retrieval of any food jar would have been exceedingly difficult here. In conclusion, it seems probable that most of the linen of Cave 1 was associated with the storage of the numerous (attested) scrolls rather than with (unattested) food storage.

Of the three examples found in the PEF, no. 20 is a short fragment of a corded border with an open weave and a count of 12 × 12 threads per cm. It is impossible to determine what kind of cloth this derived from as the fragment is too small. No. 23 survives to the dimensions of 24 × 12 cm, and is quite damaged (with holes), with two edges rolled and oversewn with two threads, 'very neatly', according to Crowfoot (1955, 33) and the corner is well-turned (showing no signs of the twisting that frequently accompanies jar-covers). The count is 13 × 11, with an open weave. No. 25 is a small fragment of blue-decorated cloth showing a selvedge.

The original textiles were, according to Crowfoot, extremely smelly, reeking of goat urine (personal communication.). She writes that the textiles were full of a 'thick dark brown dust mixed with rat and mouse droppings' (Crowfoot 1955, 18). This is consistent with Lankester Harding's observation that most of the linen had been under 15 cm of animal droppings in the cave. It was also suspected that the textiles were contaminated with Dead Sea salts. Crowfoot therefore cleaned the larger textiles using the detergent *Lissapol N*[1] 'much diluted with distilled water', and then rinsed off the detergent with water. She cleaned 'a number of smaller pieces' with soft water (Crowfoot 1951, 6; 1955, 18).

A number of different pieces of Qumran linen have found their way into British collections, including those of the British Museum, the Ashmolean (Oxford), and the Fitzwilliam Museum (Cambridge). This situation is probably due to the fact that Lankester Harding brought the linen to England for Crowfoot to work on (Crowfoot, 1951, 5) and then gave away linen to various institutions (see Bélis 2003, 227–28). From the note with an accompanying piece of Murabba'at textile in the PEF collection it is likely that the linen was given to the PEF sometime in the 1960s.

It was decided that it would be helpful for the purposes of Qumran studies for a small sample of one of the pieces to be removed for radiocarbon dating. A fragment of linen was already separated (by Crowfoot) from A. F. 23 and positioned in the top right-hand corner of the display case. It was decided to remove only this piece for analysis, avoiding any further cutting.

The perspex case was opened by the archivist Felicity Cobbing on 12 December 2001, and the piece removed by a small knife. It was cut out between two pieces of glue that attached the piece to the perspex so that no glue adhered to the actual sample. It was then placed in a sterilized jar to be sent to the Chemistry Department, University of Southern Denmark in Odense, Denmark. The original perspex case was then replaced. This process was monitored by Joan Taylor and textiles specialist Hero Granger-Taylor.

SAMPLE NUMBERS

Upon arrival at Odense the sample was marked PEF AO (AF) Linen fragment No. 23. The sample was assigned the sample number KLR-5466. In Holland it was dated under the sample number GrA-24262 (Gr for Groningen, A for accelerator).

PRE-PREPARATIONAL SAMPLE HANDLING AND TREATMENT

The sample was transferred to Risø National Laboratory and cleaned by extraction in 50 ml 99.9% ethanol in reflux in a Soxlet apparatus for eight hours, followed by extraction in 50 ml hexane for eight hours. After this the samples were dried at 60°C overnight. The pre-cleaned sample was then subjected to the normal AAA-pretreatment.

PREPARATION AND ^{14}C-DATING

For radiocarbon analysis, the sample was dated by Accelerator Mass Spectrometry (AMS) in Gröningen. AMS is a method of doing radiocarbon dating that involves small amounts of sample material being destroyed to gain a result. The sample was subjected to the chemical pretreatment called AAA (Mook and Streurman, 1983). This is the standard procedure, in order to select the proper datable fraction and remove contaminants, e.g. soil carbonates. It consists of first a treatment in 4% hydrochloric acid (the first A). This acid removes any carbonate, resins, sugars, or infiltrated humic acids present in the sample as such carbon containing compounds are considered contamination. Secondly the sample is subjected to an alkaline (second A) treatment in *ca.* 2% NaOH in order to remove tannic acids. Finally the sample is again subjected to 4% hydrochloric (third A) in order to remove any carbon dioxide absorbed during the alkaline treatment step.

After pretreatment, the sample was combusted and purified into CO_2 by an Elemental Analyser (EA), coupled on-line with a stable isotope Mass Spectrometer (MS). The EA/MS system enables precise measurements of δ^{13}C-values. The δ^{13}C-value is necessary in order to correct the ^{14}C-measurement for any possible isotopic fractionation — that is, the preferential removal (or addition) of certain isotopes relative to the others, e.g. an artificial shift in isotopic ratios such as $^{13}C/^{12}C$ or $^{14}C/^{12}C$ — that may have taken place before or during the sample preparation procedure. The principle is that if a substance, i.e. the sample, is subjected to isotopic fractionation the $\delta^{13}C$-value is shifted only half that of the $\delta^{14}C$-value, as $\delta^{13}C$ is essentially the $^{13}C/^{12}C$-ratio whereas the $\delta^{14}C$-value is essentially the $^{14}C/^{12}C$-ratio. For this sample, GrA-24262, we measured a $\delta^{13}C$-value of -24.10 o/oo VPDB (measuring unit: per mille Vienna Pee Dee Belemnite) and the carbon content of the sample was measured to be 40.8%. Both values are within the expected normal ranges. The radiocarbon age was subsequently corrected for isotopic fractionation to the standard reference value of $\delta^{13}C = -25$ o/oo VPDB, which is the normal value for terrestrial material such as linen.

The CO_2 was trapped cryogenically by a fully automated device (van der Plicht *et al.* 2000). Next, the CO_2 was collected and converted into graphite by reduction under excess hydrogen. The resulting graphite (about 1 mg) was then pressed into a target pellet, which fits into the carousel of the AMS ion source. The AMS system is a mass spectrometer especially designed for measuring the concentration of radiocarbon (^{14}C). The system is described by Gottdang *et al.* (1995) and consists of a 2.5 MV Tandetron accelerator, an ion source, which contains up to fifty-nine graphite targets and a high-energy mass spectrometer. Performance, routine operations and research highlights can be found in van der Plicht *et al.* (2000).
The radiocarbon date was measured to:

GrA-24262 1995 ± 40 BP

The quoted error is 1 standard deviation. Enough graphite was available for a duplo measurement. This duplo was meant both as a test of the reproducibility of the AMS facility and as a way to reduce the uncertainty of this important sample. The rerun came out to:

GrA-25588 1975 ± 35 BP

The difference between the two independent dates (twenty radiocarbon years) is well within the quoted error margin, and this agreement must be considered excellent.
From the two measurements we calculate the weighted average as:

1984 ± 28 BP

By convention, the ^{14}C-age is reported in radiocarbon years expressed in BP. This is an internationally agreed 'unit' defined as follows: the samples are measured with respect to an internationally agreed standard, calculated using the so-called conventional half-life, and corrected for isotopic fractionation. The meaning of BP is Before Present, where 'Present' corresponds to 1950 AD since the ^{14}C radioactivity of the standard corresponds to that year. The Radiocarbon years (in BP) have to be calibrated into the historical timescale (expressed in calB.C. or calA.D.). This is done using a calibration curve, obtained by very precise ^{14}C measurements for wood samples dated absolutely by dendrochronology (Stuiver and van der Plicht, 1998). The calibration curve has a 'wiggly' shape caused by natural ^{14}C-fluctuations in the atmosphere, making calibration and in particular the error handling not straightforward. Computer programs have been written for this purpose. Here we use the OxCal programme (Bronk Ramsey 1995; 2001), with the 2004 curves (Reimer et al., 2004; Bronk Ramsey 2005).

GrA-24262 + GrA-25588: 40 calB.C.–55 calA.D. (at ± 1 standard deviation)
50 calB.C.–80 calA.D. (at ± 2 standard deviation)

The calibrated probability distribution is shown in Fig. 4.

Considering the 1 sigma confidence level calibration result, the largest probability interval (57.6%) lies between 5 calB.C. and calA.D. 55. There are only minor probabilities for a date between 40 and 30 calB.C. (4.3%) or 20 and 10 calB.C. (6.3%).

SIGNIFICANCE OF RESULTS

Prior to this radiocarbon dating result, there have been three previous attempts to date the linen either from Qumran or the caves associated with the site. The first took place during the early days of the evolution of the radiocarbon dating method. Linen from Cave 1 was sent to W. F. Libby for analysis in November 1950. Crowfoot notes that '[f]our ounces of scrap linen were [. . .] sent by Mr. Harding to Dr. Libby of the Institute for Nuclear Studies, University of Chicago, for a Carbon 14 test' (1955, 18). These yielded a date of 1917 ± 200 (Libby 1951; Sellers 1951), estimated then as being between 167 B.C. and 237 A.D. (Crowfoot, 1955, 27, and see Bélis, 2003, 226), which was a very wide range. The date is now calibrated to be 170 calB.C.–340 calA.D. (at ±1 standard deviations).

The second attempt was done by the Tucson AMS-laboratory in 1994 on a linen sample from Cave 4 (lab sample AA-13434, DSS-26, 'linen with a leather thong', Cave 4 inventory no. 1041). The linen had a leather thong attached of the type used to fasten scrolls. The reported date was 2069 ± 40 BP, which is now calibrated at 1 sigma confidence level to be to be 170 calB.C.–40 calB.C. (at ±1 standard deviations).

Thirdly, a linen item identified as coming from Qumran Cave 2 was radiocarbon dated but it turned out to be medieval: BP 664 ± 36, or 1280 calA.D.–1390 calA.D. at ±1 standard deviations confidence level. Because of its dating and its match with other materials found by the excavators in the Wadi Murabba'at Cave 2 it is almost certain that it derives from this site and the 'Qumran' label is mistaken (Doudna, 1998).

If the linen found in Cave 1 is probably mostly associated with the storage of the scrolls in jars, then the dating of the linen has a bearing on how we date the placement(s) of the scrolls in Cave 1. However, the date of the linen should not be confused with the date of the placement(s) of the scrolls in the caves.

Linen is made from flax (*Linum usitatissimum*) that has a growth period of one season, usually three to four summer months, after which it is harvested (Hepper 1992, 166). The youngest flax leaves are used for the finest linen. After the leaves are cut they are retted (soaked in water) for about a week, dried, beaten, or rolled, combed, and spun. The radiocarbon date is the mean date of the life of the plant, which, in the case of flax harvested for linen, is a period less than a year. For all intents and purposes then, the radiocarbon date is a measure of the date that the linen was made.

It is impossible to say with certainty for any given piece of linen how long it was used prior to its arrival in Cave 1, but Crowfoot (1955, 25) points out that worn scroll wrappers, along with scrolls themselves, were not thrown out but placed in a genizah (Crowfoot 1955, 25). According to Mishnah Shab. 9:6, written down at the end of the second century of the present era, worn out sacred books or their worn-out cloths are stored away in order to hide them. The word for 'cloth' (*mitpahat*) is generic and not technical though it is used specifically for scroll-wrappers in several passages of the Mishnah (m.Kel. 28: 4; Neg. 11:11). For a prior employment of the linen Crowfoot notes how 'many of the cloths show signs of wear and tear, and have several repairs' and 'there are only one or two instances of cloths whose fringe ends seem to show no signs of fraying caused by use'. The fact that so many of the cloths are cut down from larger pieces also means there may have been a separate period of use for the larger pieces. A. F. 23 is itself cut from a larger piece, and damaged, which may then mean that from the earliest probable radiocarbon date we should add a period of use before the employment of the linen for storing the scrolls in Cave 1.

The radiocarbon date of the linen helps to clarify the date of the depositing of the scrolls in Cave 1. However, the significance of the results will be interpreted differently depending on the prior model adopted for interpreting the materials found in Cave 1. For example, if the assemblage of scrolls in jars is interpreted as a genizah then it is not necessary to confine the date of deposit to only one narrow timeframe since people could have used the cave for depositing old scrolls (with scroll wrappers) over many years. If the model adopted is a panic-hide scenario then the date will be a narrow timeframe.

On the basis of the results from these tests, it would be highly unlikely that the linen was made prior to 50 B.C., and there is a probability of 58% for the linen being made between 5 calB.C. and calA.D. 55. However, given that this is only one sample, it is at this stage wisest to stress the significance of the result of 50 calB.C.–80 calA.D. (at ± 2 standard deviations), which is a result given with 95.4% confidence, and also to consider it significant that there is the narrower range of 40 calB.C.–55 calA.D. at the 1 sigma confidence level.

If the period of use of the linen is tentatively set to one generation, i.e. twenty-five years, and the 1 sigma confidence calibration range is used, the highest probability for the date of use in Cave 1 would be 15 calB.C.–80 calA.D.

It is hoped that this result will encourage others who are currently in possession of Qumran linen to have it radiocarbon dated. The value of these dates is cumulative. This is true in the case where a hypothesis is proposed that the samples are simultaneous, in which case the sum total of many datings can yield increased precision, through procedures in which radiocarbon dates are combined and averaged. It is also true in the case where it is not assumed that the dates are simultaneous, but instead represent a prolonged interval of deposition in the caves. In this case the information might assist in estimating the start and end of the interval.

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